

Owing to the frequent occurrence of thallium in copper ores, it is very probable that this element may sometimes be present in commercial copper, and may give rise to some of the well-known, but unexplained, differences of its quality. I am at present engaged in investigating this subject, and have already found some indications of thallium in commercial products.

I have no hesitation in saying that in some of our large copper, sulphur, and sulphuric-acid works, thallium is at the present time being thrown away by the hundredweight: a very slight modification of the present arrangements of the furnaces and condensing flues, or even an examination of some of the residues, would enable nearly the whole of this to be saved. Bearing this in view, I am now in communication with several large consumers of thalliferous minerals. My applications have without exception been met with the utmost courtesy and most obliging offers of assistance, and there is therefore every probability that I shall soon have an opportunity of preparing this new element in considerable quantities, and thus be enabled to pursue the investigation with more comfort and accuracy than hitherto, when my stock of material has had to be counted by the grain.

- IX. "On the Photographic Transparency of various Bodies, and on the Photographic Effects of Metallic and other Spectra obtained by means of the Electric Spark." By Prof. W. ALLEN MILLER, M.D., LL.D., V.P. and Treas. R.S. Received June 19, 1862.

(Abstract.)

In this paper the author pursues an inquiry the commencement of which was communicated to the Chemical Section of the British Association last year. Owing to the employment of a prism of bisulphide of carbon, he was then led to believe that the photographic effects of the electric spectra produced by the different metals were in a great degree similar, if not identical. Subsequent investigations have, however, shown him that the absorbent effects of the bisulphide upon the chemical rays are so great, that the conclusions then drawn from observations made by this refracting medium require

very considerable modification. Notwithstanding the great length of the chemical spectra obtained by the aid of the bisulphide, not more than *one-sixth* or *one-seventh* of the true extent of the spectrum produced by the electric spark between various metals is procured, as may be shown by comparing the spectrum with one of the same metal furnished by the use of a lens and prism of rock-crystal.

Rock-crystal, however, possesses but a comparatively small refractive and dispersive power, whilst it almost always affords some trace of double refraction in one portion or other of the spectrum procured by its means.

In searching for some singly refracting medium which should possess sufficient refractive and dispersive power to enable it to be used advantageously in the construction of lenses and prisms suitable for this inquiry, the author was led to examine the photographic absorption of a variety of colourless substances which appeared perfectly transparent to the luminous rays. The experiments detailed in the first portion of the present paper refer to this absorbent action of various media upon the chemical rays of the spectrum; whilst the second portion of the paper is devoted to a description of the electric spectra of some of the more important elementary bodies, and the effect of varying the gaseous media in which the sparks producing these spectra are made to originate.

1. *The Photographic Transparency of Bodies.*—In the experiments upon the absorbent action of the different media, the source of light employed was the electric spark obtained between two metallic wires (generally of fine silver), connected with the terminals of the secondary wires of a ten-inch induction-coil. The light, after passing through a narrow vertical slit, either before or after traversing a stratum of the material the chemical transparency or *diactinic* quality of which was to be tested, was allowed to fall upon a quartz prism placed at the angle of minimum deviation for the mean of the refracted rays. Immediately behind this was a lens of rock-crystal, and behind this, at a suitable distance, the spectrum was received upon a collodion-film coated with iodide of silver; this was supported in the frame of a camera, and after an exposure, generally lasting for five minutes, the image was developed by means of pyrogalllic acid, and fixed with cyanide of potassium.

The general results of these experiments were as follows :—

1. Colourless bodies which are equally transparent to the visible rays, vary greatly in permeability to the chemical rays.

2. Bodies which are photographically transparent in the solid form, preserve their transparency in the liquid and in the gaseous states.

3. Colourless transparent solids which exert a considerable photographic absorption, preserve their absorptive action with greater or less intensity both in the liquid and in the gaseous states.

Whether the compound is liquefied by heat or dissolved in water, these conclusions respecting liquids are equally true. The perfect permeability of water to the chemical rays, conjoined with the circumstance that in no instance does the process of solution seem to interfere with the special action upon the incident rays of the substance dissolved, renders it practicable to submit to this test a great number of bodies which it would otherwise be impossible to subject to this species of experiment on account of the extreme difficulty of obtaining them in crystals of sufficient size and limpidity.

Glass vessels cannot be employed to contain the liquids during the trial. Flint-glass, crown, hard white Bohemian, plate-glass, window-sheet, and Faraday's optical glass, all, even in thin layers, shorten the spectrum by from three-fifths to four-fifths or even more of its length. Mica produces a similar effect. Indeed, the only substance which the author found could be employed with advantage is rock-crystal cut into thin slices and polished. The value of this material in researches upon the more refrangible end of the spectrum was pointed out by Prof. Stokes and M. E. Becquerel several years ago. In order to hold the liquids for experiment, a small trough was prepared by cutting a notch in a thick plate of plate-glass, the sides being completed by means of thin plates of quartz, which were pressed against the ground surfaces of the plate-glass by the aid of elastic bands of caoutchouc; a stratum of liquid of 0·75 inch in depth was thus obtained for each experiment.

The substances which, after atmospheric air and certain other gases, are most perfectly diactinic, are rock-crystal, ice, as well as pure water, and white fluor-spar. Rock-salt is scarcely inferior to them, if at all. Then follow various sulphates, including those of baryta, and the hydrated sulphates of lime and magnesia, as well as those of the alkalies. The carbonates of the alkalies and alkaline

earths, as also the phosphates, arseniates, and borates, are likewise tolerably transparent, though saturated solutions of phosphoric and arsenic acids exerted considerable absorbent power; so also did those of the alkalis, potash, and soda, possibly from the presence of a trace of some foreign colouring matter, as those liquids had an extremely faint greenish tinge.

The soluble fluorides, as well as the chlorides and bromides of the metals of the alkalis and alkaline earths, are freely diactinic, but the iodides are much less so, and exhibit certain peculiarities. All the organic acids and their salts which were tried by the author exerted a marked absorptive action upon the more refrangible rays. Amongst those subjected to experiment were the oxalates, tartrates, acetates, and citrates, those mentioned first in order having the greatest absorptive action. It is, however, much more difficult to obtain organic compounds in a state of purity sufficient to furnish trustworthy results, than is the case with the salts of the inorganic acids. The author, therefore, expresses himself with more reserve upon some of these organic bodies, particularly the acetates, than in other cases. The different varieties of sugar are freely diactinic.

Amongst the salts of inorganic acids, the nitrates are the most remarkable for their power of arresting the chemical rays. A solution of each of these salts, in all the instances tried, cut off all the more refrangible rays, and reduced the spectrum to less than a sixth of its ordinary length. The chlorates, however, do not participate in this absorptive power to nearly the same extent.

Although the sulphates, as a class, are largely diactinic, the sulphites are much less so; and the hyposulphites cut off about three-fourths of the length of the spectrum, leaving only the less refrangible portion.

Of eighteen different liquids tried by the author, two only can be regarded as tolerably diactinic, viz. water, which is eminently so, and absolute alcohol, which, however, exhibits a considerable falling off. The liquids which follow are mentioned in the order of their chemical transparency, those most transparent being mentioned first:—Dutch liquid, chloroform, ether; then benzol and distilled glycerin, which differ but little; then fousel oil, wood-spirit, and oxalic ether, which are also nearly alike; acetic acid, oil of turpentine, glycol, carbolic acid, liquid paraffin, boiling at 360° F., and bisul-

phide of carbon. Finally, terchloride and oxychloride of phosphorus, although perfectly colourless and limpid, arrest all the chemical rays.

The experiments upon aëriform bodies yielded important results; they show but little coincidence with those of Tyndall on the absorptive power of the gases for radiant heat. These experiments were made by interposing in the track of the ray between the vertical slit and the quartz prism, a brass tube two feet long, closed at each end air-tight by means of a plate of quartz. Each gas or vapour in succession was introduced into the tube, and the results compared with those produced by causing the rays to traverse the tube when filled with atmospheric air.

Amongst the colourless gases, oxygen, hydrogen, nitrogen, carbonic acid, and carbonic oxide exhibit no absorptive power.

Olefiant gas, protoxide of nitrogen, cyanogen, and hydrochloric acid exert a slight but perceptible absorbent effect. But in the case of coal-gas the absorptive action is extremely marked, the more refrangible half of the spectrum being cut off by it abruptly. The absorption exerted by sulphurous acid is still more powerful and as sharply defined; sulphuretted hydrogen and the vapour of bisulphide of carbon exhibit a still more decided absorbent action; the effect of the terchloride and oxychloride of phosphorus is not less marked. This absorbent action of these different compounds of sulphur and phosphorus is very striking.

Coal-gas appears to owe its remarkable power of arresting the chemical rays to the presence of the vapour of benzol and other heavy hydrocarbons; since the vapour of benzol at 65° , diffused to saturation through a column of atmospheric air two feet long, exerts a still more powerful absorptive effect than coal-gas.

On the other hand, the effect of a similar arrangement, in which the vapour of ether, of chloroform, and of oil of turpentine was substituted for that of benzol, gave effects which, though perceptible, were much less marked. An arbitrary scale is laid down, by which a comparative estimate of the absorptive power of each compound, whether solid, liquid, or gaseous, may be effected with tolerable accuracy.

With a view of facilitating the production of a spectrum on a flat field, at a uniform distance at all points from the prism, the author instituted a series of experiments, in which a small metallic speculum

was substituted for the lens of rock-crystal ; but the loss of chemical power in the reflected rays was so considerable, and this loss occurred so unequally at different points, that the method was abandoned. The results of the photographic action of light reflected at an angle of 45° from the polished surface of several of the principal metals is given. The reflexion from gold, although not very intense, was found to be more uniform in quality than that from any other metal that was tried. Burnished lead also gave very good results. The reflexion from silver is singularly deficient in some portions of the less refrangible rays, although in most other parts the reflexion is tolerably perfect, except for rays of extremely high refrangibility.

2. *The Electric Spectra of the Metals.*—The author proceeds then to detail his experiments upon the spectra obtained by causing the sparks caused by the secondary current from the induction-coil to pass between electrodes composed of various elementary substances, and he gives photographs of the impressions obtained from collodion negatives of a considerable number of different elementary bodies. The spectra were procured by arranging a quartz-train in the manner already described. Among the elements so examined are the following :—

Platinum.	Arsenic.	Copper.
Palladium.	Tellurium.	Aluminum.
Gold.	Tungsten.	Cadmium.
Silver.	Molybdenum.	Zinc.
Mercury.	Chromium.	Magnesium.
Lead.	Manganese.	Sodium.
Tin.	Iron.	Potassium.
Bismuth.	Cobalt.	{ Graphite, and Gas-coke.
Antimony.	Nickel.	

The commencement of each spectrum in its less refrangible portion is similar in nearly all cases ; and as it is this portion only which is transmissible through bisulphide of carbon, this circumstance explains the similarity of all the spectra procured by the author from different metals in his earlier experiments, already laid before the British Association. In the more refrangible parts of the spectrum great and characteristic differences between the results obtained with the different metals are at once manifest. In some cases, as in those of copper and nickel, the action is greatly prolonged in the more refrangible extre-

mity, whilst the intense and highly characteristic spectrum of magnesium is much shorter.

In many cases metals which are allied in chemical properties exhibit a certain similarity in their spectra. This occurs, for example, with the magnetic metals, iron, cobalt, and nickel, and with the group embracing bismuth, antimony, and arsenic. The more volatile metals exhibit generally the most strongly marked lines. Cadmium, for instance, gives two intense groups. Zinc, two very strong lines near the less refrangible extremity, three near the middle, and four nearly equidistant lines towards the termination of the more refrangible portion, whilst in the spectrum of magnesium the chemical action is almost suddenly terminated near the middle by a triple group of very broad and strong lines.

It will be observed, on examining the photographs of these spectra of the various metals, that the impressions, particularly in the more refrangible portions, consist of a double row of dots, running parallel with the length of the spectrum, and forming the terminations of lines rather than lines themselves, as though the intense ignition of the detached particles of metal, necessary to furnish rays capable of exciting chemical action, had ceased before the transfer of these particles to the opposite electrode had been completed.

If each electrode be composed of a different metal, the spectrum of each metal is impressed separately upon the plate, as is evident on examining the photographs.

When alloys are employed as electrodes, the spectrum exhibited is that due to both the metals; but if the metals made use of are approximatively pure, the spectrum is hardly to be distinguished from that of the pure metal. In the case when alloys are used as electrodes, it is not always the more volatile metal which impresses its spectrum most strongly. A specimen of brass, for example, containing 38 per cent. of zinc, gave a spectrum which could not be distinguished from that of pure copper, though an alloy of three parts of gold and one of silver gave a spectrum in which the lines due to silver predominated.

The author then proceeds to describe a number of experiments upon the transmission of sparks between electrodes of different metals in a current of several different gases. The apparatus employed consisted of a glass tube; into the side an aperture was drilled,

which could be closed by a plate of quartz; the ends of the tube were closed by ground brass plates, each supporting a pair of brass forceps, into which the electrodes were fitted; through the axis of the tube a current of each gas was transmitted at the ordinary atmospheric pressure.

Among the gases thus tried were hydrogen, protoxide of nitrogen, carbonic acid, carbonic oxide, olefiant gas, marsh-gas, cyanogen, sulphuretted hydrogen, sulphurous acid, nitrogen, and oxygen. The spectrum obtained from the same metal varied considerably in these different media. In hydrogen the intensity of the spectrum was greatly reduced, and the more refrangible rays were wanting, but no new rays made their appearance. In carbonic acid, carbonic oxide, olefiant gas, marsh-gas, and cyanogen, the special lines due to the metal were produced, but in each a series of identical lines appeared, and these new lines were referable to the carbon contained in each of these gases. Each gas exhibits special lines which are continued across the spectrum, and are never interrupted like those of the metals.

The author observed that many of these gases, such as protoxide of nitrogen, hydrochloric and sulphurous acid, presented a considerable obstacle to the passage of the sparks from the induction-coil.

X. "On the Long Spectrum of Electric Light." By Professor GEORGE G. STOKES, M.A., Sec. R.S. &c. Received June 19, 1862.

(Abstract.)

The author's researches on fluorescence had led him to perceive that glass was opaque for the more refrangible invisible rays of the solar spectrum, and that electric light contained rays of still higher refrangibility, which were quite intercepted by glass, but that quartz transmitted these rays freely. Accordingly he was led to procure prisms and a lens of quartz, which, when applied to the examination of the voltaic arc, or of the discharge of a Leyden jar, by forming a pure spectrum and receiving it on a highly fluorescent substance, revealed the existence of rays forming a spectrum no less than six or eight times as long as the visible spectrum. This long spectrum, as formed by the voltaic arc with copper electrodes, was exhibited